

# Resilience of the UK Food System in a Global Context: key messages for stakeholders

Insights from a major interdisciplinary research  
programme to enhance the UK's food security  
in a changing world







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# Enhancing the UK's food security in a changing world

On the following pages you will find key messages from Resilience of the UK Food System in a Global Context, a major interdisciplinary research programme. The £14.5 million, five-year programme was launched in 2016 with funding through the cross-government Global Food Security programme, with support from BBSRC, ESRC, NERC and Scottish Government. It draws to a close in December 2021.

Undertaking collaborative research spanning UK universities, research institutes and many other stakeholders, 13 Projects have produced new evidence and recommendations for policy and practice. These will help to identify and develop interventions to strengthen UK food security. Each of the 13 Projects has focused on one or more aspects of the food system:

1. Optimising the productivity, resilience and sustainability of agricultural systems and Landscapes
2. Optimising the resilience of food supply chains
3. Influencing food choice at individual and household level to both improve health and enhance food systems resilience

Together the Projects have produced a rich and diverse set of outputs that help to further our understanding of how to enhance the resilience of the food system.

The Programme has promoted knowledge exchange to intensify the quality and impact of the research, both within the Programme and with a wide range of external stakeholders. The overarching Programme messages are drawn from this activity.

## Getting the most from this report

Pages 4 and 5 set out the Programme-level messages. These are followed by summary messages from each of the 13 Projects, listed for stakeholders working in government and policy areas, for those in the agri-food industry, for NGOs with a food-related focus, and for the finance and investment community. These are complemented by an overall Project message.

These messages are intended as entry points for further exploration and action. Further details of the research can be accessed via the Project pages on the Programme website: [www.foodsystemresilienceuk.org](http://www.foodsystemresilienceuk.org) or using the contact details provided.

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## Three overall themes



Launched:  
2016

Total funding:  
£14.5  
million

13  
interdisciplinary  
projects

150+  
Science papers  
published

# How can we enhance food system resilience?

## Key messages

1. The UK food system comprises a range of production systems, supply chain processes and related 'activities' that deliver a range of 'outcomes' of fundamental importance to society. Outcomes include food and other ecosystem goods and services, health status, and employment and livelihoods. **There is an urgent need to enhance the resilience of food system outcomes to an increasing diversity, frequency and intensity of shocks and stresses.**
2. **Shocks** are sudden, surprising events leading to short-term interruptions (but which may result in longer-term changes) to components of the food system that impact food system activities and hence the 'outcomes'. Examples are trade wars, food scares, extreme weather and geophysical events, election and referendum results, and pandemics. **Stresses** are pressures or tensions exerted on the system, normally leading to longer-term disruptions. Examples include changes in demography and social and cultural norms, the political economy, urbanisation, agricultural intensification, automation, natural resource degradation, and climate change. **Shocks and stresses can interact** to amplify their respective impacts. COVID-19, initially a shock and now a stress, has further highlighted a number of vulnerabilities in the UK food system as already identified by individual GFS FSR Projects.
3. There is no overall 'solution' as **strategies to enhance food system resilience need to be context specific.** Further, prescriptive approaches to a specific food system component may have negative consequences for other components.
4. Discussions on how to enhance food system resilience need to be framed by the answers to **four key questions**. (i) Where do we need to increase resilience? (resilience of what); (ii) What do we need to build resilience against? (resilience to what); From who's perspective is enhanced resilience needed? (resilience for whom); and (iv) Over what time period is enhanced resilience needed? (resilience for how long).
5. There are **three strategies for enhancing resilience (the '3Rs')**. (i) **Robustness**: aim to resist disruption to existing food system outcomes (maintain status quo); (ii) **Recovery**: aim to return to existing food system outcomes after disruption (bounce back); (iii) **Reorientation**: aim to accept alternative food system outcomes before or after disruption (bounce forward). All three strategies require Reorganisation, i.e. adapt the food system processes and activities.
6. **Sustainability and resilience are not the same.** A strategy aimed at 'robustness' or 'recovery' may not necessarily be sustainable, and a strategy aimed at enhancing sustainability may not be resilient. But the twin aims of **sustainability and resilience can be positively synergistic within a 'reorientation' strategy.**
7. **Enhancing resilience of individual production systems/processes/activities does not automatically enhance resilience of the whole food system.** There is therefore a need to clarify resilience understanding across different actors to avoid perverse outcomes of resilience-building actions. Co-ordinated action will lead to systemic innovations. These are innovations requiring multiple organisations and/or stakeholders to coordinate their activities in order to innovate and/or put the innovation into practice.
8. **Enhancing UK food system resilience using combinations of the '3Rs' will require a range of interrelated actions in policy and practice,** based on evidence derived from interdisciplinary research and applied across spatial, temporal and jurisdictional scales. These also need to support sustainable, clean growth and the net zero carbon agendas. Examples include:

- a. deepening food system structural, informational and institutional knowledge;
- b. adopting appropriate codesigned technologies;
- c. strengthening social capital between consumers, retailers and producers at local-to-regional-levels;
- d. balancing better the power arrangements between producers and retailers;
- e. catalysing a change in household and local food culture;
- f. seeking an optimum trade balance between domestic and imported food and agri-inputs;
- g. promoting a circular food economy including recycling more and designing out waste; and
- h. supporting natural resource managers in maintaining the ecological processes that underpin food systems.

## Stakeholder-specific messages

9. **Governmental policy formulation should take a whole food system approach** across government departments and agencies and spatial, temporal and jurisdictional levels. This will better identify the range of potentially negative consequences across the system of a given policy target. It should be based on latest food systems and foresight approaches.
10. **Industry should proactively address the negative relationship between food price on one hand, and food system sustainability and resilience on the other** to reorientate towards a more healthy, sustainable and resilient food system. For example, sustainably produced and healthy food could be subsidised by industry-led strategies on less sustainably produced and unhealthy products which – as part of a reorientation strategy – would also enhance food system resilience.
11. **NGOs covering multiple agenda should play a more substantial, evidence-based role** in holding government and business to account. As many NGOs focus on a specific part of the food system, more collaboration is needed among them to take a whole systems view of resilience. This would strengthen their position to (i) promote a circular food economy and its embedded paradigms; (ii) engender and facilitate negotiated resilience across the supply chain; (iii) influence consumer choices; (iv) campaign for minimizing negative effects of weak risk-sharing mechanisms across the food system; and (v) analyse the resilience of supply chains from social viewpoints such as workers' welfare.
12. **Finance and Investment sectors should include short and long-term financial stress testing of their portfolios to a wide range of exposures** including implications for investments from disruption in production and food supply chains due to extreme weather and climate change, to trade restrictions, and/or to labour shortages (from e.g. pandemics); and reputational risk due to changing environmental attitudes of consumers.
13. **The research establishment (comprising researchers and funders) will have an increasingly important role in helping to enhance the resilience of the UK food system.** Key issues to boost research impact include:
  - a. **promoting a circular food economy** and its embedded paradigms.
  - b. **prioritising stakeholder co-design** in food system resilience research.
  - c. **facilitating relationship building** with stakeholders, especially for new entrants into a given agenda.
  - d. **removing systemic barriers to stakeholder inclusion** and their co-funding.
  - e. **minimising 'stakeholder fatigue'** by coordinating engagement better across the research arena.
  - f. **promoting more rigorous boundary setting** for research on the food system in its broadest sense.
  - g. **enhancing cross-Council, and UKRI-foundation collaboration** to prioritise inter- and trans-disciplinarity.
  - h. **maintaining the newly-found emphasis on food system research.**

# BananEx



## Securing the future of the nation's favourite fruit

Banana supply can be made more resilient if sustainably produced and certified produce is appropriately costed to reflect its true price and encourage investment in more resilient grower and supply chain practice.

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Resilience to climate change and disease impacts, and support for farmer recovery following shocks in producer countries is most effective if included in policies that promote sustainable production systems.	Supply chain industries are best supported by policies aimed at social sustainability.	Clearer policies on advertising and marketing aimed at encouraging consumers to purchase certified sustainable bananas at higher price can best support producers in adopting more resilient practice.
<b>2 Industry policy &amp; practice</b>	Industry-led investment in sustainable and resilient agriculture, e.g. soil health, and new banana varieties, is needed to develop more resilient production.	Although supply chains are historically highly efficient and resilient, further considerations of stresses and shocks are warranted to ensure uninterrupted banana supply.	Encouraging consumers to purchase certified sustainable bananas at higher price can support producer adoption of more resilient practice.
<b>3 NGO policy &amp; practice</b>	Analysis and critique of various sustainable certification systems can identify most effective approaches to contribute to enhanced resilience.	Engagement in analysis of supply chain welfare and support of workers can identify and promote examples of good practice.	NGO campaigns can re-enforce industry encouragement of consumers to purchase certified sustainable bananas at higher price.
<b>4 Finance &amp; investment</b>	Investment in research into sustainable production methods (e.g. soil health, disease resistance, improved certification schemes) will identify more resilient production practices.	Investing in companies with fair and equitable supply chains will encourage growers to adopt more sustainable and resilient practices.	Investing in retailing companies that strive for more resilient supply chains will likely provide the best medium- to long-term return.

**i** More than five billion bananas are purchased in the UK each year however the single internationally traded variety is under threat from a virulent strain of Panama Disease. BananEx has investigated the resilience of banana production and supply from biological, ecological, economic and social perspectives to safeguard the supply this important fruit.

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# Diverseafood



## Evaluating the potential of integrated multi-trophic aquaculture (IMTA) to improve nutrition and ecosystem sustainability in the UK

The development of IMTA and low trophic aquaculture, targeted changes to feed composition and increased circularity of seafood business models, have the potential to increase seafood nutritional value and decrease local nutrient enrichment, while diversifying supply and increasing resilience.

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<b>1 Government policy &amp; practice</b>	Nutrient neutrality through IMTA can be encouraged through whole-water body approaches, considering non-proximal offset and operationalisation of ecosystem services.	Considering trade-offs between global and local sustainability is needed when global shifts from fish meal to plant-based feeds can increase local environmental impact and lower fish nutritional value.	Policies that promote IMTA and low-trophic aquaculture, together with public understanding of aquaculture ecosystem services can increase social acceptance.
<b>2 Industry policy &amp; practice</b>	IMTA of seaweed, bivalves and salmon reduces the local footprint of salmon farms and increases the nutritional value of extractive species, which can be optimised with modelling tools as FYNE.	The alignment of business models with circular economy principles improves seafood business resilience, particularly if businesses have a diverse customer base and range of suppliers.	Emotion-laden information on the environmental impact of aquaculture negatively affects consumers' culinary experience of seafood.
<b>3 NGO policy &amp; practice</b>	When advocating for shifts in practices it is important to consider unintended consequences, and the diversity of aquaculture systems.	Industry-level NGOs can leverage the supply chain power to improve consumer-reach and drive large-scale changes in behaviour towards sustainability and health.	NGOs have a valuable role to play in influencing consumer behaviour and advocacy on nutrient neutrality of aquaculture through IMTA and low-trophic species, which could be very important to local communities.
<b>4 Finance &amp; investment</b>	Blue fund managers can use models such as FYNE to estimate the environmental and nutritional impact of investment projects.	The failure to contain the environmental impact of the supply chain exposes the sector to significant long-term risks which would impact investments.	The ability to successfully retail IMTA products to consumers could provide an incentive in increasing investment in IMTA production.

IMTA = integrated multi-tropic aquaculture

**i** Diverseafood has explored how the diversification of UK aquaculture and transition to integrated multi-trophic aquaculture (IMTA) can increase the contribution of seafood to a healthy and sustainable diet and lead to environmentally and socio-economically sound production. The findings will inform understanding of the key barriers to aquaculture diversification.

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# FF&V



## Increasing resilience to water-related risks in the UK fresh fruit and vegetable system

Enhanced resilience of the UK fresh fruit and vegetable (FF&V) supply chain is essential for health and enterprise but needs to be based on integrated policy and practice to avoid negative environmental externalities.

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<b>1 Government policy &amp; practice</b>	Policies to support the creation of a stronger institutional framework for water allocation rights would help growers build resilience to water-related risk.	Minimising the ‘off-shoring’ of environmental impacts (e.g. FF&V imports from water-stressed regions) warrants detailed policy formulation.	An information campaign on FF&V choices has the potential to both improve health outcomes and enhance food systems resilience.
<b>2 Industry policy &amp; practice</b>	The formation of grower groups would improve water allocations and facilitate the sharing of knowledge on enhancing resilience to pest outbreaks.	Retailers can improve risk-sharing mechanisms to enhance upstream actors’ resilience.	Food manufacturers can revisit produce specifications with respect to multiple end-products and resilience-enhancing measures.
<b>3 NGO policy &amp; practice</b>	NGOs can be powerful advocates for vulnerable growers on risk-sharing mechanisms.	NGOs can play a valuable role as neutral brokers in helping to negotiate resilience across the whole supply chain.	NGOs can help encourage consumers to choose FF&V from more sustainable and resilient supply chains.
<b>4 Finance &amp; investment</b>	Investment in water resources will be needed to help growers adopt more resilience practices.	Long-term investments in climate adaptation will be more effective than short-term investments in helping supply-chain actors adopt more resilience practices.	Investing in consumer-facing advertising and retail that promote consumption of UK-grown FF&V enhance the UK FF&V system resilience.

**i** Fresh fruit and vegetables – in demand all year round – are often grown in the driest parts of the UK or imported from countries where water resources are under stress. FF&V has explored resilience to three kinds of risk related to water: its physical availability, reputational risks, and regulatory risks.

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# I Know Food



## Integrating knowledge for food systems resilience

Farmer-centric innovation strategy, the creation of robust international supply chains and a reorientation of UK food insecurity policy can help to build UK food system resilience.

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Behavioural tools for pro-environmental behaviours help to provide stability and resilience for farmers in face of regulatory change.	The use of governance, trade and environmental data helps to build an assessment framework for supply chain risks.	Taking into account the heterogeneity, fragility and stigma associated with the UK food bank system will help shape policies that better meet the needs of those experiencing food insecurity.
<b>2 Industry policy &amp; practice</b>	A farmer-centric approach to innovation and technology is increases innovation adoption by farmers in the UK.	Data science can help industry by playing a key role in reorientating supply chains to minimise risks and by measuring impacts of shocks on UK consumption.	Unveiling the heterogeneity of the UK food aid system allows more informed and coherent policy making to address food insecurity and to enable retailers to develop more coherent inclusive approaches to food poverty.
<b>3 NGO policy &amp; practice</b>	Advocating for enhanced relationships, frames and practices in agricultural science and technology can support robustness, safety and recovery of farmers.	Data on high-risk commodities can be a basis for collaboration between NGOs and private sector.	Mapping the UK food bank system has shown its fragility in providing food security for vulnerable families.
<b>4 Finance &amp; investment</b>	More focus is needed on codesigning technology and innovation with farmers in order to de-risk investment in technology development.	Data science and governance approaches should be used as tools to unpack high risk commodities and have the potential for corporates to de-risk their supply chains and enhance their brand reputation.	Financial policy changes need highlighting to reduce inequalities by, eg, increasing Universal Credit payment to low-income families.

**i** Systems of food production, trade and consumption are increasingly vulnerable to interconnected political, economic and ecological shocks. I Know Food has investigated the sources of these vulnerabilities to produce datasets, information resources, engagement approaches and business tools that will assist stakeholders in developing mitigation and adaptation strategies.

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# PIGSustain



## Predicting the impacts of intensification of and future changes to the UK pig industry

Enhanced resilience requires a careful balance between providing healthy and nutritious diets, practicing environmentally sustainable production, and safeguarding livelihoods for all in the supply chain.

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Maintaining the UK’s high standards of pig health and welfare to support export while ensuring that import levels are balanced will support the maintenance of a resilient and sustainable pig industry.	Supporting high animal health and welfare can lead to a consistent supply of UK pork, waste reduction and enhanced production efficiency and sustainability.	Tailoring dietary health campaigns to different geographical and socio-economic populations can help achieve more targeted and successful health outcomes that are right for different groups within the population.
<b>2 Industry policy &amp; practice</b>	Resilience is reduced when animal numbers decrease. To ensure the system is resilient we need to focus on maintaining levels of breeding stock with an emphasis on farming smarter and more sustainably.	Investing in a skilled and appropriately compensated workforce would help to ensure a smooth supply of pork further down the supply chain, but also is pivotal in supporting resilience across the whole supply chain.	Targeted marketing campaigns could be more efficient and less costly, getting the right product to the right consumer more effectively.
<b>3 NGO policy &amp; practice</b>	NGO activity to promote and support the maintenance of a sustainable, high welfare UK pig industry would guard against retailer demands for imported lower welfare products.	By supporting opportunities for sustainable foreign trade, that balances domestic supply and export opportunities, NGOs and farmer unions can help to smooth domestic supply and demand variations.	Targeted NGO awareness campaigns against poor animal welfare would encourage consumers to choose high welfare, UK sourced pork products.
<b>4 Finance &amp; investment</b>	Transformation is needed to make the UK pig industry environmentally sustainable and appealing for future export markets, but this cannot be at a cost to livelihood.	Investment in the practical transformation of more efficient forms of transport will optimise resilience in the supply chain.	Targeted educational investment to help consumers understand where their food is coming from in key areas could help to promote healthier eating practices.

**i** The UK pig industry faces multiple risks including changes in climate, trade, feed, retail prices and consumption patterns. PIGSustain has taken a multi-disciplinary, integrated systems approach to modelling and assessing the resilience of the UK pig industry, currently and in the future.

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## The role of phosphorus in the resilience and sustainability of the UK food system

Linking sustainable nutrient (P) stewardship in a circular economy, with scale-appropriate governance and learning models provides a route to enhanced long-term food and water security.

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Whole food systems modelling of nutrient (P) flows combined with participatory stakeholder engagement can identify routes to improve efficiency, preserve resources, and maintain a healthy environment.	Effective recycling of renewable products and practice change is required to reduce UK reliance on imported fertilisers and feedstuffs requires regional governance.	Healthier food choices will lower system nutrient (P) demand and nutrient loading stresses on our environment.
<b>2 Industry policy &amp; practice</b>	Principles and practice of nutrient (P) circularity along with experiential learning will improve environmental performance of food systems.	Scale-connected food supply chains offer greater opportunities to more closely operate and manage circular nutrient (P) economies.	Transitioning to healthier diets will increase phosphorus loading to sewage works but offers greater opportunity to recover and recycle nutrients
<b>3 NGO policy &amp; practice</b>	Nutrient (P) stewardship should account for variable biophysical and socioeconomic catchment characteristics for delivery of multiple ecosystem services.	Legacy soil P reserves in soil provide a short-term buffer to future disruptions in supplies of imported P fertilisers.	Greater public awareness of the impact of food choices on the sustainability and resilience of nutrient (P) supply and use in food systems is required.
<b>4 Finance &amp; investment</b>	Incentives are required to deliver uptake of nutrient (P) stewardship in support of ecosystem service delivery and public goods.	Industry-Government funding is needed to support innovation and implementation of nutrient (P) recovery technology.	Strategic research funding and investment in public awareness are required to identify the linkages between nutrient (P) inputs, food quality and human health.

**i** Phosphorus (P) is a key nutrient for crop and livestock production however global reserves of phosphate rock are finite and its inefficient use causes water pollution. This project has developed the first National Adaptation Strategy for more efficient and sustainable phosphorus use in the UK food system.

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# Resilient Pollinators

## Modelling landscapes for resilient pollination services

Pollinator monitoring and targeting agri-environmental measures towards vulnerable and high-value areas can help stem pollinator loss, increase the resilience of UK crop yields and improve the aesthetic value of landscapes.

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Agri-environment features are effective but need to be better targeted to areas with pollinator deficits (e.g. Eastern England).	Public and professional pollinator monitoring is needed to identify and understand how to enhance the resilience of the food supply chain.	Public awareness campaigns will highlight the importance of maintaining diverse local pollinator communities.
<b>2 Industry policy &amp; practice</b>	Collaboration between land managers, government and wildlife organisations can identify the best way of supporting local bees, especially in East England.	Actors along the supply chain and their investors need to recognise the importance of pollinators in maintaining crop production and their potential vulnerability to service losses in third countries.	Encouraging consumers to include a range of UK-grown crops in their diets can help support pollinator populations.
<b>3 NGO policy &amp; practice</b>	NGO support for farmers who appropriately manage habitats can maintain pollinator diversity, especially in vulnerable areas.	Advocating greater awareness of the role of pollinators will help to underpin the supply chain.	NGOs can deliver messages about the benefits of locally-grown fresh produce on pollinator populations
<b>4 Finance &amp; investment</b>	Investing in diversified, sustainable farming systems, especially at large scales is important to maintaining and restoring local pollination services.	To enhance resilience of UK's global supply chains, investments to support pollinator habitats outside UK are as important as supporting those within UK.	As consumers become more aware of pollinator importance, investors can support food businesses that source from pollinator-friendly landscape management to help them compete in a crowded market.

**i** Pollination services by insects, particularly bees and hoverflies, underpin millions of pounds of crop production within the UK. This project has explored the impacts of current land management practices on the resilience of pollinator natural capital across the UK and assessed the feedbacks that changes in pollinators would have on economic and socio-cultural wellbeing.

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# Resilient Dairy Landscapes



## Socio-technical innovation for dairy resilience and sustainability

Expanding and integrating ecosystem markets can help transform food production systems by promoting regenerative agriculture, sequestering carbon and increasing the resilience of agri-businesses to environmental change.

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Dairy production systems have the maximum potential for enhancing sustainability and resilience if integrated in ecosystem markets.	New ecosystem markets have the potential to buffer predicted reductions in public funding for agriculture post-2024, supporting dairy farms as the foundation for more resilient dairy supply chains.	Policies developed to encourage consumption of dairy products from farms engaged in Landscape Enterprise Networks (LENs) would enhance overall ecosystem resilience.
<b>2 Industry policy &amp; practice</b>	The dairy sector has the potential to tap into significant new income streams via ecosystem markets and hasten the transition to more regenerative systems and retain resilient production.	Regionally co-procuring ecosystem services via Landscape Enterprise Networks (LENs) boosts green finance and shares risk across the food supply chain actors	Labelling to promote products developed from milk supplied from farms engaged in regional ecosystem markets will encourage customer uptake.
<b>3 NGO policy &amp; practice</b>	Advocating for the integration of regional ecosystem markets with national carbon markets can potentially increase funding for dairy as a component of more resilient regenerative agriculture and conservation.	NGOs can help overcome the disconnect between potential supply chain customers of ecosystem functions and those who can deliver value.	Lobbying for legislation requiring advertisers to promote products derived from resilient dairy landscapes, and for supported by clearer labelling, would help build customer awareness.
<b>4 Finance &amp; investment</b>	The UK Farm Soil Carbon Code offers opportunities for investors and protects their investment while incentivising a large-scale transition to regenerative agricultural practices that are more sustainable and resilient.		

**i** Resilient Dairy Landscapes has explored the trade-offs between farmers’ livelihoods, the natural environment and the stable supply of reasonably priced dairy products. By devising and testing innovations, the project aimed to increase the resilience and sustainability of dairy farming in a rapidly changing world.

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# ResULTS



## Resilience in upland livestock systems

There are a huge range of different environments and production systems. Policies developed for majority systems may have very large unintended consequences for more marginal areas.

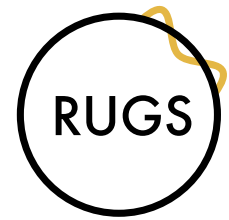
	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Financial support mechanisms (e.g. for environmental activities, support for public goods) are often designed inappropriately for upland areas, even where these areas have very high nature value	Centralised infrastructure (e.g. abattoirs) reduces resilience and the flexibility to secure alternative supply chains, and add value of provenance.	Include environmental factors, including biodiversity impacts, when designing the 'Well Plate'
<b>2 Industry policy &amp; practice</b>	A circular economy approach facilitates recycling of appropriate wastes to livestock and secures value chains for by-products (e.g. wool).	Improved integration of the value chain and fair returns can provide less volatile and improved income streams. This needs transparency, and information exchange along the supply chain	More transparency is needed regarding where products are sourced from, and how they are produced (particularly in pre-prepared foods).
<b>3 NGO policy &amp; practice</b>	There is a need for more nuanced applications of reforestation and rewilding, so that it is the right tree in the right place, and the right rewilding in the right place, - avoiding damaging rural communities, biodiversity and existing peat carbon stocks.	Promotion of local beef and lamb, produced without large external inputs, such as soya-based feeds or artificial fertilisers, can add to sustainability and resilience.	NGO campaigns need to recognise that not all meat production has the same environmental negative impact and some systems have positive impacts, for example on biodiversity
<b>4 Finance &amp; investment</b>	Recognise the need to balance investment in carbon offsetting with upland livestock industries and livelihoods in rural areas, avoiding causing rural depopulation.	Develop financial schemes that enable small-scale food supply chain enterprises to benefit from investment and allow them to participate in carbon markets in appropriate ways	Support for small-scale, local food enterprises should be linked to larger markets.

**i** ResULTS has examined how beef cattle and sheep farmers in upland areas of Northern England and Scotland can improve their resilience to environmental, economic, and social change, and what impact their actions to improve resilience will have on food supplies, natural resources and society.

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## Resilience of the UK food system to global shocks

Focussing on commodities that can be produced more sustainably in the UK than elsewhere, and trading in those that cannot, can limit the food system’s environmental footprint and increase its resilience

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Incentives to reduce the consumption of animal products and move towards a more sustainable diet (i.e. lower in animal products) would reduce agricultural encroachment on global natural land important for biodiversity.	Agricultural subsidies or UK trade barriers improve resilience of household food security to global shocks by incentivising agricultural production in the UK.	Within the UK, non-price interventions that influence individuals’ preferences are likely to be more successful than price-based policies in changing diets.
<b>2 Industry policy &amp; practice</b>	The viability of some sectors, such as beef and dairy farming, and crops, such as oil crops and starchy roots, is more sensitive to the design of subsidy or trade regimes.	Low functional diversity levels, inflexible contracts and homogenous processes may increase supply chain vulnerability. A degree of power in terms of financial capacity, robust logistics and cooperation can enable firms to better mitigate shock impacts.	The food industry plays a key role in supporting consumers to make healthier and more sustainable choices.
<b>3 NGO policy &amp; practice</b>	The complexity involved in the food system means ‘local’ foods can only be part of an improved system	For NGOs focusing on the environment, pet foods have a non-negligible environmental impact and should therefore be included in the food system discussion.	Work to reduce food losses is important, but consumption in-excess of nutritional requirements accounts for a similar quantity of food as discarded food waste, but with health as well as environmental consequences.
<b>4 Finance &amp; investment</b>	UK agricultural investment should focus on food commodities which the UK can produce more sustainably than the rest of the world.	UK food prices will continue to be exposed to volatility in the global market, as the UK will remain reliant on imports even with higher subsidies or trade costs.	Social media is able to create demand-driven shocks by rapidly shaping attitudes and behaviours towards food consumption.

**i** The interconnected nature of the global food system means local shocks or changes can cause impacts in other regions. RUGS examined how the global food system deals with shocks and changes while developing our understanding of the impact that these events have on the UK food system.

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# Rurban Revolution



## Can ruralising urban areas through greening and growing create a healthy, sustainable and resilient food system?

Growing more of our fresh fruit and vegetables in towns and cities provides a potential triple win of helping us to diversify our supplies, enhance urban ecosystems and environments, and promote healthier diets.

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	There is untapped potential in urban spaces for the production of sustainable food that promotes multiple outcomes, including health and social wellbeing.	Small-scale local producers in urban environments can be better connected into processing and retail value chains with more focused mechanisms and incentives.	Engaging or being exposed to urban food growing can influence food choices and lead to healthier diets.
<b>2 Industry policy &amp; practice</b>	Integrating urban food growing into residential and commercial property development can support healthier and more sustainable and resilient communities.	Mechanisms for integrating local urban farmed foods into procurement procedures/ supply chains can help to diversify supplies and deliver local economy, community, and sustainability benefits.	Food grown in urban areas requires careful marketing to ensure it is appealing to consumers.
<b>3 NGO policy &amp; practice</b>	Collaboration between NGOs with multiple agendas relating to urban food growing and gardening could make a strong collective case for increasing urban food production.	Urban food growers can have a more prominent role in supplying local, resilient supply chains if supported by strong NGO advocacy.	Advocating urban food growing as a key component of social cohesion also has the potential to positively effect dietary health and personal resilience.
<b>4 Finance &amp; investment</b>	Urban food production, processing and retailing have a high potential for business model innovation and provide opportunities for investors to integrate environmental, social, and governance (ESG) factors into the investment process from the start		

**i** Rurban Revolution has sought to examine how the ruralisation of urban areas or ‘rurbanisation’ – by increasing greening and food growing in these areas – could increase availability, access and preference for fruit and vegetables, alleviate pressure on land use, and shorten supply chains.

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 [www.foodsystemresilienceuk.org/rurban-revolution](http://www.foodsystemresilienceuk.org/rurban-revolution)



# SEEGSLIP



## Sustainable economic and ecological grazing systems – learning from innovative practitioners

The adoption of low-input pasture-fed approaches for beef and sheep production and promotion of the value of this approach could enhance the UK food system’s resilience

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Policies and incentives to encourage PFLA farming and information sharing practices can contribute to the resilience and sustainability of grassland landscapes from economic, ecological and social perspectives	PFLA practices can contribute to resilient food supply chains by shortening them and reducing input costs thereby ensuring farmer viability.	Customers who are better informed about health and environmental benefits of PFLA approaches are more likely to buy these products.
<b>2 Industry policy &amp; practice</b>	PFLA approaches can help achieve a balance across the economic, environmental and social aspects of livestock practices by promoting sustainability and resilience.	Actors in the food supply chain can support local PFLA practitioners through buying directly from them where possible.	Sourcing livestock products from PFLA members will help industry to deliver more environmentally and socially sustainable practices.
<b>3 NGO policy &amp; practice</b>	There can be real benefits to sharing land and animal management and food marketing practices within farmer groupings	Advocating beneficial PFLA practices including short supply chains and reduced inputs can contribute to resilient food supply chains.	NGOs can help to highlight positive benefits of practices such as those employed by the PFLA to help consumers make informed choices.
<b>4 Finance &amp; investment</b>	Investing in suppliers who focus as much or more on resilience and sustainability as on productivity will provide best returns.	Shorter food chains can contribute to supply chain resilience and hence are sound options for investors.	As environmental, health and animal welfare issues become more prominent, retailers who promote PFLA sources will increasingly attract market share.

PFLA = Pasture-Fed Livestock Association

**i** Pasture for Life (Pfl) certified producers use approaches that can potentially enhance the efficiency of grass use and provide environmental, economic and livestock benefits. SEEGSLIP has holistically evaluated the ecological, agronomic and social impacts of this approach to grazing management and its potential.

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# TGRAINS



## Transforming and growing relationships within regional food systems for improved nutrition and sustainability

Building social capital can catalyse a transformation in household and local food culture and agricultural practices with positive feedback loops for building resilience and sustainability.

	<b>A Optimising the productivity, resilience and sustainability of agricultural systems and landscapes</b>	<b>B Optimising the resilience of food supply chains</b>	<b>C Influencing food choice at individual and household level to both improve health and enhance food systems resilience</b>
<b>1 Government policy &amp; practice</b>	Embedding CSAs into local policies can help local authorities develop and execute better targeted and more resilient food strategies.	Building relationships back into the food system by promoting community-scale supply chains can lead to healthier and more sustainable outcomes.	Food inequality can be addressed through the CSA model by subsidising the system, e.g. (double-value) vouchers for low-income families to access CSA-produced food.
<b>2 Industry policy &amp; practice</b>	Increasing the production of plant proteins may require investment as these crops tend to be less profitable than major cereals.	Participating with other actors across the supply chain will co-create change based on stakeholder buy-in and cooperation from the start.	Promoting the value of CSAs is a means for a) creating routes to market via direct purchase and b) diversifying on-farm production.
<b>3 NGO policy &amp; practice</b>	Better collaboration with farmers to promote new and diverse horticultural production can achieve diets that are both healthy and sustainable.	Food aid charities collaborating with farms can develop more resilient models of food accessibility via community-scale supply chains.	Considering how farms can be incorporated into community-scale initiatives can promote healthier, more sustainable diets.
<b>4 Finance &amp; investment</b>	Investing in higher yielding plant protein and diversified plant protein sources could improve profits, reduce the need for subsidies and reduce the fertiliser/pesticides required.	There is potential for more investment in regional processing facilities which contribute to the provenance and value of 'locally-produced' food.	The large gap between the amount of legumes consumed and what we need to be consuming to meet Eat Lancet targets create opportunities for investment in plant protein.

CSA = Community supported agriculture, a partnership between farmers and consumers

**i** TGRAINS has combined a place-based approach with agricultural modelling to assess whether sustainable and nutritious diets that are socially, culturally and economically desirable can be produced within regional landscapes. The research team worked with producers, consumers and retailers to understand the impact of direct relationships between actors.

 [www.foodsystemresilienceuk.org/tgrains](http://www.foodsystemresilienceuk.org/tgrains)

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# What is food system resilience?

Food system resilience is the system's capacity to deliver desired outcomes when exposed to stresses and shocks. Enhancing resilience of a food system can be achieved in three ways:

## ■ Robustness

**The ability of the food system to resist disruptions to current outcomes by preventing shocks and stress impacting food system activities.** Examples include food system actors adopting more heat-tolerant crops and more diverse farming systems, taking actions to ensure there is sufficient natural habitat to support pollinators, or a food processor or retailer having multiple supply chains.

## ■ Recovery

**The ability of the food system to return to prior outcomes following disruption (bounce back).** Examples include system actors taking out insurance to re-instate crops or physical infrastructure, or using smart technologies to re-stock grocery supply and delivery following a temporary shortage.

## ■ Re-orientation

**The ability of food system to deliver acceptable alternative outcomes before or following disruption (bounce forward).** Examples include accepting diets based on a wider range of agricultural products thereby spreading risk, or incentivising food supply chains to transform outcomes of health, environment and enterprise.

Aiming for any of these three ways requires re-organisation, i.e. making changes in how the system operates. This is termed 'adaptation'; food system actors adapt their activities (the 'what we do': farming, processing retailing, etc) to maintain, or to be able to return to, or to transform the outcomes (the 'what we get': food supply, livelihoods, ecosystem services, etc).

'Adaptation' therefore refers to changing the food system activities. 'Transformation' refers to changing the food system outcomes. Activities do not spontaneously change but do so in response to a change in a driver. This could be, for instance, a new regulation, a period of extreme weather or a new set of trading arrangements. This change in driver(s) will lead to adapting from method 1 to method 2 in response to the new set of conditions. Similarly, outcomes do not spontaneously transform but as a result of adapting activities. Hence, aiming for transformed food system outcomes requires adapting food system activities which will be in response to changed food system drivers.

## ■ Why does food system resilience matter?

Our diets are highly varied and we expect a wide range of foodstuffs all year round. Environmental, biological, economic, social and geopolitical shocks and stresses already act as disrupting drivers to make the UK food system vulnerable to disruption. As the UK imports around half of its food, changes in trade arrangements due to EU-exit coupled with the shock (and now stress) of COVID-19 are further, major disrupting drivers. We need to enhance the resilience of our food system. The challenge is to determine how best to do this.

# Resilience of the UK food system

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